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ECL 190

THE ISOTHERMAL CUP

The isothermal cup is a passive device which rapidly cools coffee to a drinkable temperature and maintains it there for approximately 3/4 of an hour. It was designed and developed during the period of 1961-70 at Ryan Enterprises, Los Angeles, California. Patents in the United States and 11 foreign countries were granted in 1971.

This case examines not only a product and a design philosophy but also the broader aspects which relate engineering, marketing, business and finance.

 Written by George A. Sousa II and Thomas W. Tesche under the supervision of Professors J. M. Henderson and R. F. Steidel with financial support from the National Science Foundation.

INTRODUCTION

Jack Ryan has a continuing history of producing and implementing creative design. He traces his important educational experiences from early tutoring by his older brother through a lab technician's job at North American Phillips while still in high school. He received a Bachelor's Degree in Electrical Engineering at Yale in 1948 and in 1949 a degree in Industrial Management. Currently there are 174 U. S. patents in his name and over 1000 world wide. This case is the examination of one of his products and the design philosophy it exhibits.

After working for some time, first at Raytheon and then with Mattel, Jack Ryan established Ryan Enterprises which he runs concurrently with his other commitments. Ryan Enterprises creates new ideas for consumer products. They specialize in taking an idea, developing it into a product design and licensing it for manufacture. The licensee completes manufacturing design, and then manufactures and markets the product with Ryan Enterprises receiving license fees and royalties on sales. In this manner a good return for smaller cash investment is accompanied by high motivation of the manufacturer to market his product ambitiously. When a design leaves Ryan Enterprises it is a complete product, needing only final polishing to mate it to the manufacturing process most suitable to the licensee.

It is significant to see the design steps which Mr. Ryan feels are necessary to produce a successful product. These four stages of design are:

Feasibility design	- Does the raw idea work?
Preliminary design	- Can the raw idea be made into a product?
Product design	- What is the complete configuration of this product?
Manufacturing design	- How can this product be manufactured at a reasonable cost?

A combination of limited partners and full and part time employees comprise the personnel of Ryan Enterprises. The common denominator is demonstrated creativity or unique past performance.

Quantitative data supplemented the feeling that he just couldn't keep a cup of coffee at a satisfactory temperature long enough to consume it. Figure 1 shows the temperature transient of a typical ceramic coffee cup. The coffee leaves

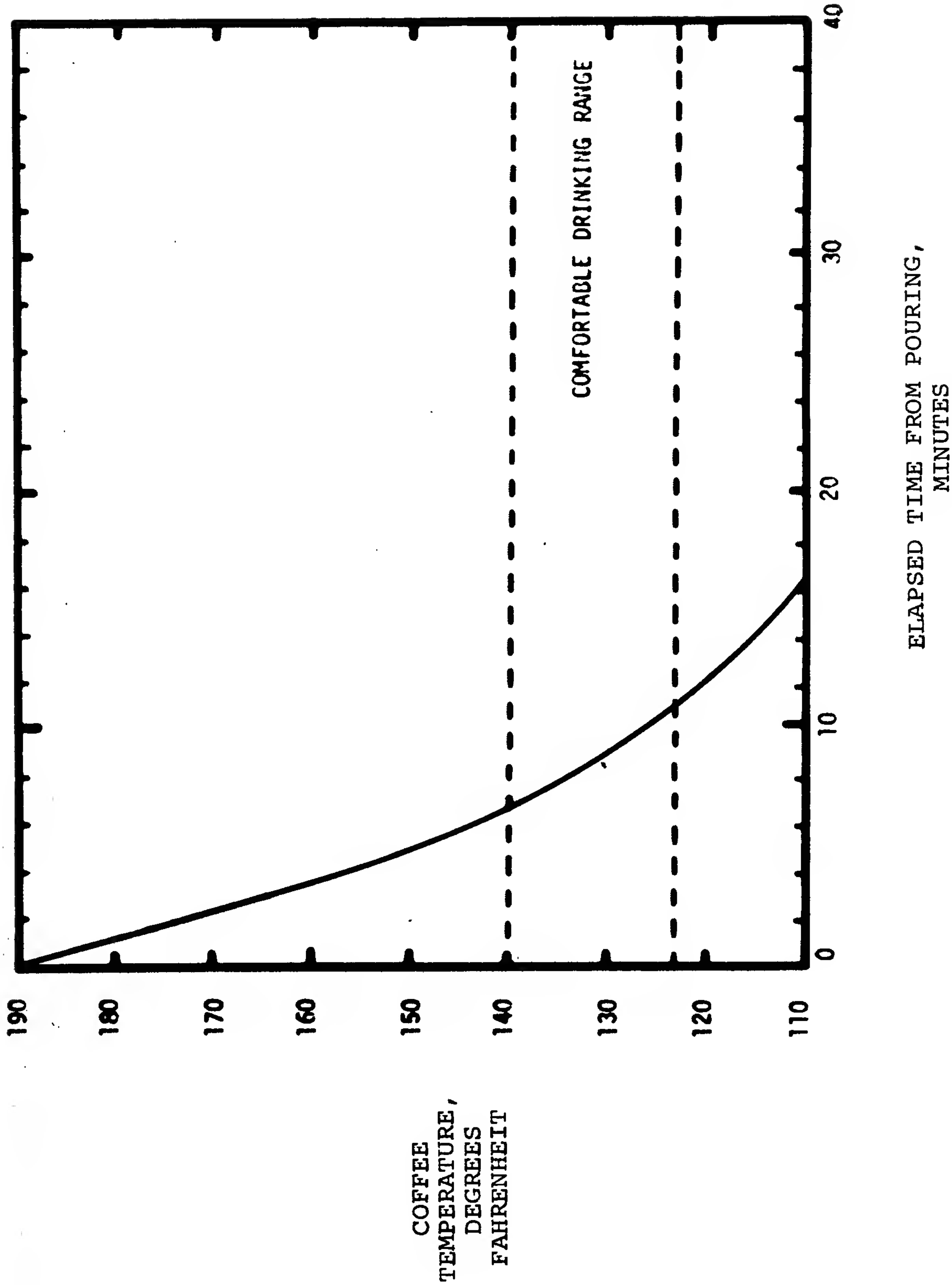
the pot at a temperature above 190°F., which is too warm for consumption. Note that an unstirred cup of coffee takes 5 minutes to cool to 140°, the highest temperature in the preference range of most coffee drinkers. Only four minutes after the coffee has become cool enough to drink, it drops below 124° and is too cool for most people.

An insulated coffee cup makes some things worse. Figure 2 shows the temperature transient of an insulated cup. While the coffee will now stay in the optimum temperature range 13 minutes, it now takes 19 minutes to cool to a drinkable temperature. This is a distinct disadvantage in the ten minute coffee break.

Mr. Ryan attempted to cool his coffee by attaching a turned aluminum anode cooler cap to the end of a pencil. By inserting this heat sink in a freshly poured cup of coffee, the temperature would rapidly be reduced to a drinkable level. While this was a workable scheme, it had several notable disadvantages. First, it was slightly messy. What do you do with a coffee soaked pencil on your desk? Second, it is not an easy process to control. Unless you monitored the cooling by sipping while stirring, it was very easy to overcool. The final insult was that if you did cool the coffee to the right temperature for an immediate drink, in four or five minutes it would be too cold to enjoy. As a stopgap measure, the cooler had merit, but it was not a solution.

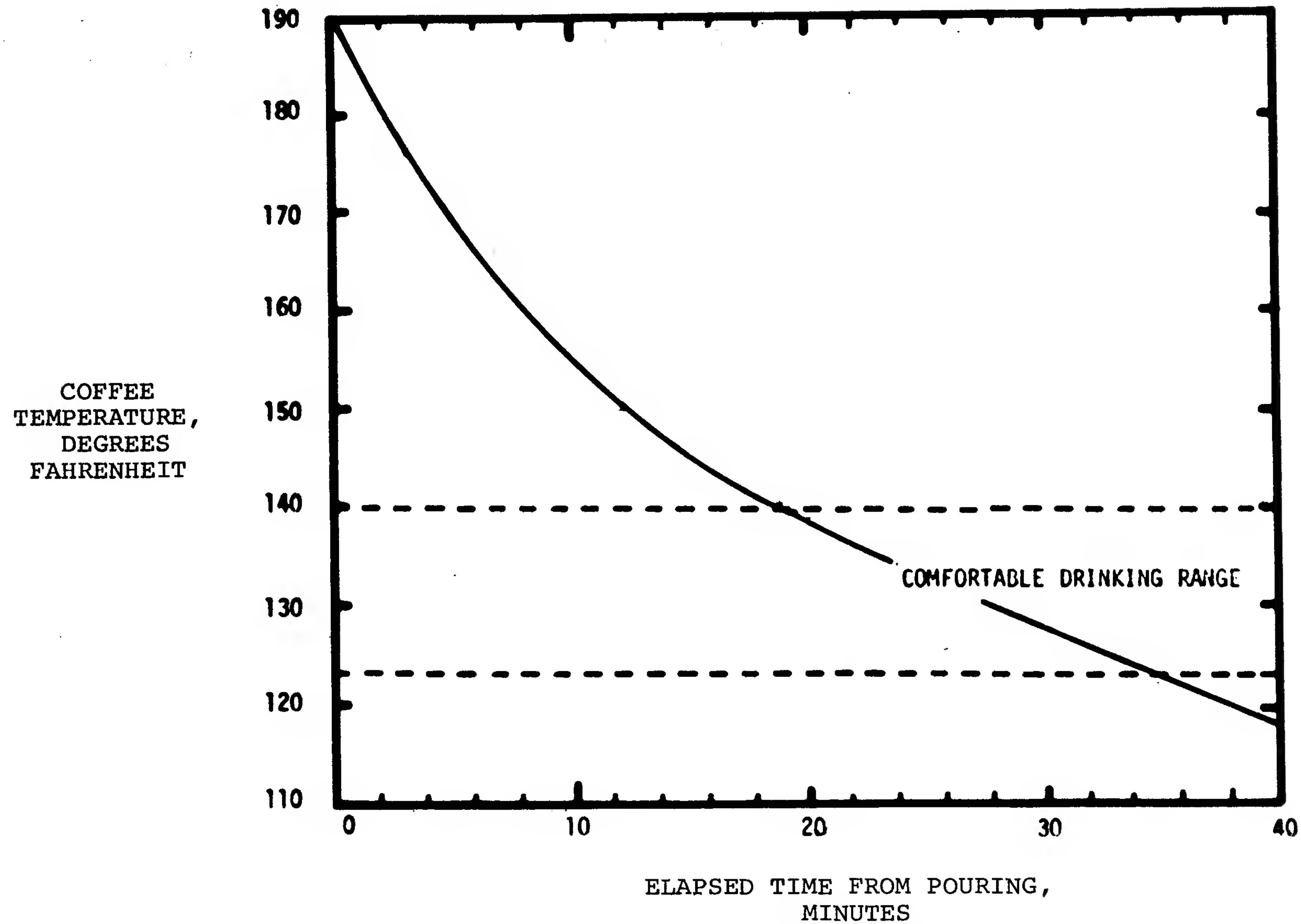
FEASIBILITY DESIGN

The project would have stayed at this point except for a thought Mr. Ryan had in 1960 on an airplane returning from New York. Why couldn't the phase change of a material be used to cool and store the excess heat of liquid foods? In phase change, the excess heat could be removed quickly and with fewer immediate irreversible losses. This should both decrease cooling time and increase the time in the optimum temperature range. An analogous argument from Fluid Mechanics can be made for illustration. Given a tall thin bucket and a short fat bucket which contain equal amounts of water, the tall thin bucket would have a greater head. If equal sized exits were opened in the respective bottoms of the two containers, the tall thin bucket would empty faster. This is due to the greater average potential between fluid and surroundings for the tall bucket. Equating the heat stored in a cup of coffee to the water in the analogy, storage at 140° instead of 190° would have the same advantage as storing water at the lower heads. It would cool slower after rapidly dropping to 140°.



Temperature History of Coffee in a Common Ceramic Cup

FIGURE 1



Temperature History of Coffee in an Insulated cup

FIGURE 2

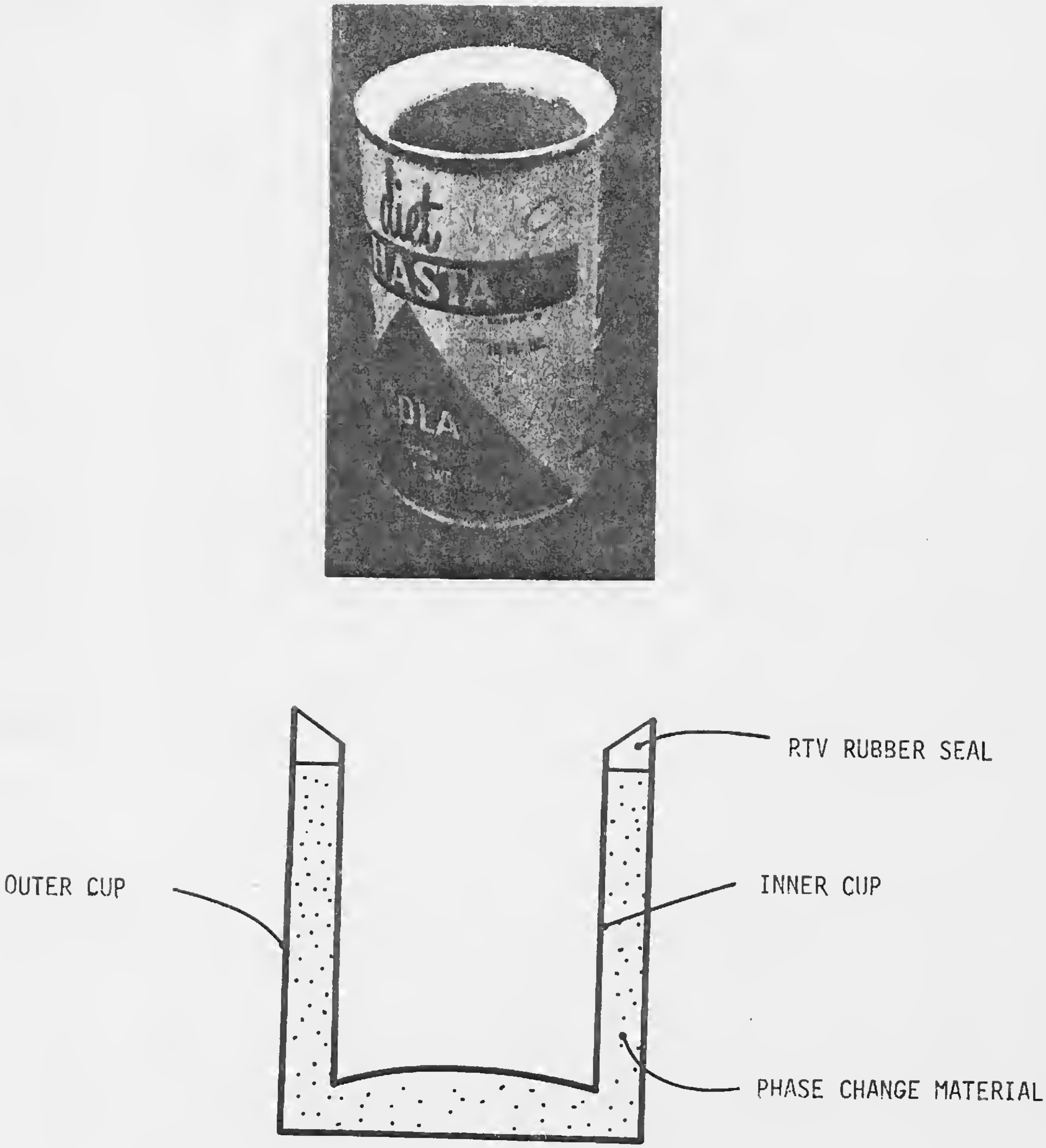
Arriving back at the laboratory of Ryan Enterprises, Mr. Ryan proposed the idea to his head designer, Warren Kabot. After some discussion, they decided that the idea had enough merit to warrant a feasibility design. An informal survey of temperature preferences was undertaken in the laboratories of Ryan Enterprises. For each trial, a cup of coffee was poured and the employee was asked to sip it until it cooled to the highest temperature he thought comfortable. This temperature was recorded and the step repeated for the lowest temperature which was satisfactory to each person's taste. This quick survey defined the range of temperature preference between 150° and 130°. This quick survey also illustrated Mr. Ryan's belief that only methods appropriate for the current stage of design would be used. A complete market survey with computerized data analysis was not justified for an unproved idea.

The first feasibility prototype shown in Figure 3 was constructed of two tin cans and a calculated amount of a Cerro Alloy. Cerro Alloys are a family of nine low temperature melting metals used in specialized pattern and die making applications. The particular alloy used in the prototype was Cerrobend which has a melting point of approximately 150°. With the Cerrobend sandwiched between the inner and outer cans and room temperature vulcanizing rubber (RTV) used as un upper seal, the cup was tested. The response was immediate and impressive. As estimated, the coffee temperature dropped rapidly to the melting point of the Cerrobend. Further, even with the highly conductive metal exterior of the cup, the temperature of the coffee was maintained within the desirable range for approximately 20 minutes.

Despite the success of the initial cup, Cerrometals were never considered for use in a production model. First, they were too expensive and second, the prototype shown while holding only 8 oz. of coffee weighed over 4 pounds. The Cerrobend proved only one thing, the basic feasibility of the design idea. It took only one week of discussion and a few hours of work by a technician to prove feasibility. Now would come the more difficult search for an appropriate material for production models and a product design.

PRELIMINARY DESIGN

As a first step it was necessary to consider the general size and shape of the proposed product. Cups on the market at that time were examined. Most held between five and seven ounces with mugs containing up to nine or ten ounces. The Ryan cup was going to have a large fixed size to accomodate the phase change material and insulation. As this would yield the



The Cerrobend Feasibility Prototype

FIGURE 3

"heft" of a mug, it was decided to approximate the capacity of a mug, about 8 ounces.

In regular use the greatest heat loss is at the free surface of the liquid. A minimization of the free surface would lead to the tall, thin shape of a test tube. This was not acceptable as marketing felt that to sell the Ryan cup, it had to look like a cup. A compromise between function and appearance led to the projected shape of a tall 8 ounce mug. As a mug it could be artistically pleasing and at the same time reduce free surface area.

A final sizing consideration was the amount of phase change material to be incorporated in the middle layer of the mug. A simple computation would yield this quantity if the amount of heat to be stored was set. This in turn depended on the number of consecutive cups for which the operation was to remain constant. If, for example, all the material completely changed phase for one cup of coffee, which was quickly consumed, the excess stored heat energy would not allow a cup poured immediately thereafter to cool rapidly to the optimum temperature. Survey and experimentation resulted in the decision to allow enough phase change material for one and a half cups of coffee. The data showed that while a significant portion of the market would drink fast enough to overload a one-cup heat capacity model only the rare coffee drinker would finish one cup and pour the next before at least half the heat of fusion was dissipated.

It was fortuitous that Maxwell House coffee performed a coffee taste, temperature and consumption survey at this time. It clarified and corrected the temperature preference ranges and the speed of drinking figure that the Ryan designers had estimated with their in-house surveys. The original 150-130° range was modified to 140-124° as this better satisfied 80% of the population. The one and a half cup heat capacity conclusion was supported by these additional consumption figures. The greater precision of this survey was appropriate to the greater investment that followed in the later stages of design.

In an attempt to obtain a practical phase change material, the Chemical Encyclopedia and several chemists were consulted. The material sought needed several specific properties. The melting point had to be in the area of 145°F. It had to be available in sufficient quantity at reasonable cost. And it had to be non-toxic so that a leak in the inner cup would not lead to a lawsuit. The first week's work yielded several suggestions most of which were semi-exotic salts of various chemicals. These failed because ingestion caused a reaction which ranged from unpleasant to serious. Reaching "P" in the encyclopedia, paraffin was tried. But, while a melting temperature of 150° was listed, tests of common commercial paraffin

showed that instead of a precise melting point, it had a large mushy range caused by various components melting at slightly different temperatures. This complicated fulfillment of the basic premise of storing excess heat in the heat of fusion to be returned to the contents as they start to cool below the melting point of the phase change material.

An examination of organic materials resulted in the consideration of beeswax. Unlike the paraffin tried, beeswax exhibited the classic well defined melting point and heat of fusion. It was not toxic like the salts suggested, and the melting point of 155° was in the right range. This justified a preliminary design and prototype, using beeswax between a turned nylon outer cup and a thin aluminum inner cup. Amid much excitement, the cup was tested and results were disappointing. It didn't seem to do much more than hold liquid. After examination, two problems were found. While using Cerrobend, there had been no problem with conduction of heat throughout the filler material and no trouble coupling the inner cup's heat transfer to the filler material. With beeswax, only a small layer of wax melted close to the aluminum; then further heat transfer was greatly reduced. The hot aluminum didn't have a great deal of surface area and could not transfer much heat through the poor conductivity of the liquid beeswax.

The initial failure with plain beeswax serves to illustrate another principle of operation in Ryan Enterprises. It is felt that if you don't make some mistakes you aren't working fast enough. This in no way relieves anyone from the responsibility of minimizing his errors but does say that optimum work output does not come at zero errors. Progress was made in this prototype but a great deal of further development was still left before arrival at a complete product design.

PRODUCT DESIGN

Jack Ryan saw the problem in two parts, thermal coupling and conduction. First, the heat of the coffee must be transferred quickly and efficiently through the inner cup into the phase change material. Thermal coupling between the inner cup and the phase change material must be complete. Second, the contacted material must conduct the heat throughout the inner layer during both heating and phase change.

Some thought produced various improved coupling schemes. It was hoped that improved coupling over a wider area would automatically improve total conduction. With this in mind various finned prototypes were designed and constructed. In this scheme the inner cup had fins on the surface contact with the

phase change material. A cup of this design is shown in Figure 4. Designs with circular and horizontally placed fins turned in aluminum on the exterior of the inner cup were tried. All turned-fin prototypes had one thing in common. They were unsatisfactory. Two adverse effects were being encountered. The production price was too high and the heat capacity of the increased mass of the metal became the dominant factor in heat transfer. The idea behind a change in phase is quick removal of excess heat by storage in the heat of fusion of the inner material. Now a prohibitive amount of heat was being used to raise the temperature of the great mass of aluminum and as such was not contributing effectively to the phase change energy storage. The system was overballasted with aluminum.

Other configurations for increased heat transfer area were tried. A piece of sheet metal was lanced to produce tabs at right angles to the main sheet surface. This sheet was then rolled to form a cylinder around the thin inner cup as shown in Figure 5. This was much less costly than other fin schemes and was not overly massive. The difficulty came, however, in insuring conduction between the inner cup and the lanced fins. Experimental results were disappointingly similar to those with the first beeswax prototype, and this idea was rejected.

A primary emphasis of the Ryan design philosophy is that the bounds of all ideas should be explored. After questions like "how much is too much?" and "how little is too little?" are answered, the full scope of the design can more readily be seen. So, while the previous steps were being completed, several other avenues of capitalization were considered. One of these was proposed to Maxwell House. It was suggested that an inexpensive model using the phase change scheme should be produced as a semi-disposable advertising gift. To this end a folded aluminum inner cup was proposed with a styrofoam outer cup. The aluminum was to be folded as paper is for a cupcake cup, thereby increasing surface area by approximately a factor of 8. No interest was shown by the coffee manufacturers; subsequently this hard to clean configuration was rejected. The folded aluminum shape was also tried as a conduction aid between inner and outer cups at approximately the same time as the lanced metal liner, but was judged similarly less than satisfactory.

Reference has been made to the inner cup in much of the previous discussion. Its evolution is of interest. Mr. Ryan feels that more time is wasted on designs which are eventually rejected due to economic considerations than for any other reason. In anticipation of the question of economics, a process for producing an inexpensive inner cup was sought. Its main criteria were conductivity, durability and ability to accept a suitable finish. Various machining, stamping and

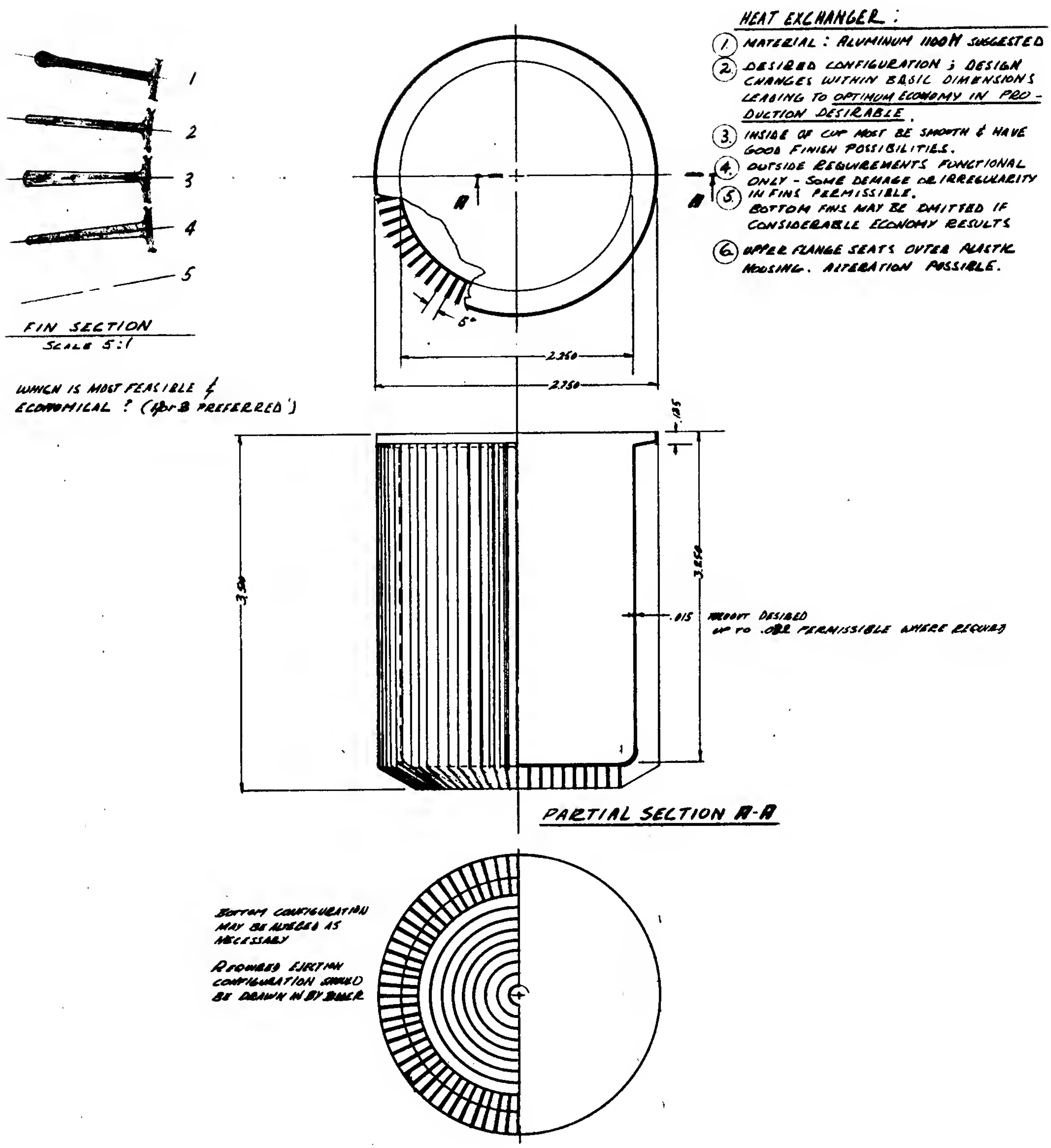
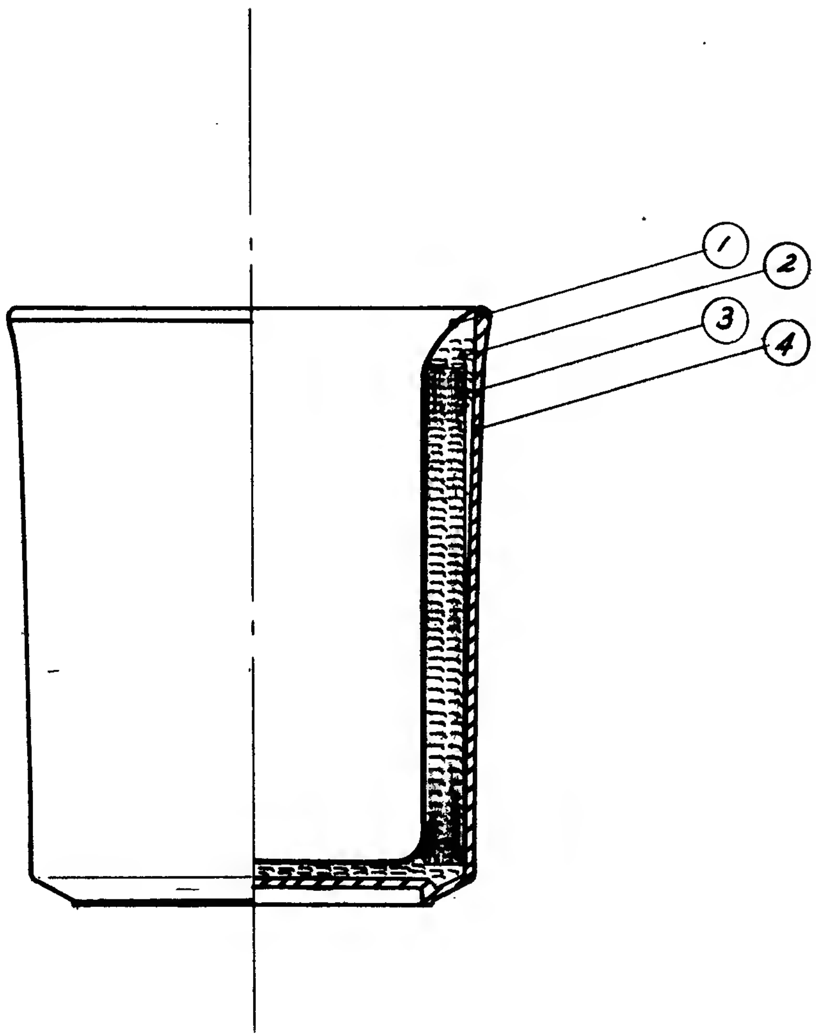

HEAT EXCHANGER :
1. MATERIAL : ALUMINUM 1100H SUGGESTED
2. DESIRED CONFIGURATION ; DESIGN CHANGES WITHIN BASIC DIMENSIONS LEADING TO OPTIMUM ECONOMY IN PRODUCTION DESIRABLE.
3. INSIDE OF CUP MUST BE SMOOTH & HAVE GOOD FINISH POSSIBILITIES.
4. OUTSIDE REQUIREMENTS FUNCTIONAL ONLY - SOME DAMAGE OR IRREGULARITY IN FINS PERMISSIBLE.
5. BOTTOM FINS MAY BE OMITTED IF CONSIDERABLE ECONOMY RESULTS
6. UPPER FLANGE SEATS OUTER PLASTIC HOUSING. ALTERATION POSSIBLE.
1
2
3
4
5
FIN SECTION
SCALE 5:1
WHICH IS MOST FEASIBLE & ECONOMICAL ? (1 or 3 PREFERRED)
A
A
5°
2.250
2.750
.125
3.50
3.250
.015
DESIRED
UP TO .032 PERMISSIBLE WHERE REQUIRED
PARTIAL SECTION A-A
BOTTOM CONFIGURATION MAY BE ALTERED AS NECESSARY
REQUIRED EJECTION CONFIGURATION SHOULD BE DRAWN IN BY

FIGURE 4



(1) DRAWN ALUMINUM CUP .020 THK .0550
ANODIZE .0325

(2) PARAFFIN MATL 3oz. .0159

(3) ALUMINUM CORRUGATION (.006 MATL #.03) .05
DIP BRAZE .04

(4) POLYPROPYLENE HOUSING (MATL #.0465) .0578
BOND TO CUP MATL. .005

ASSEMBLE .018

TOTAL : .2734

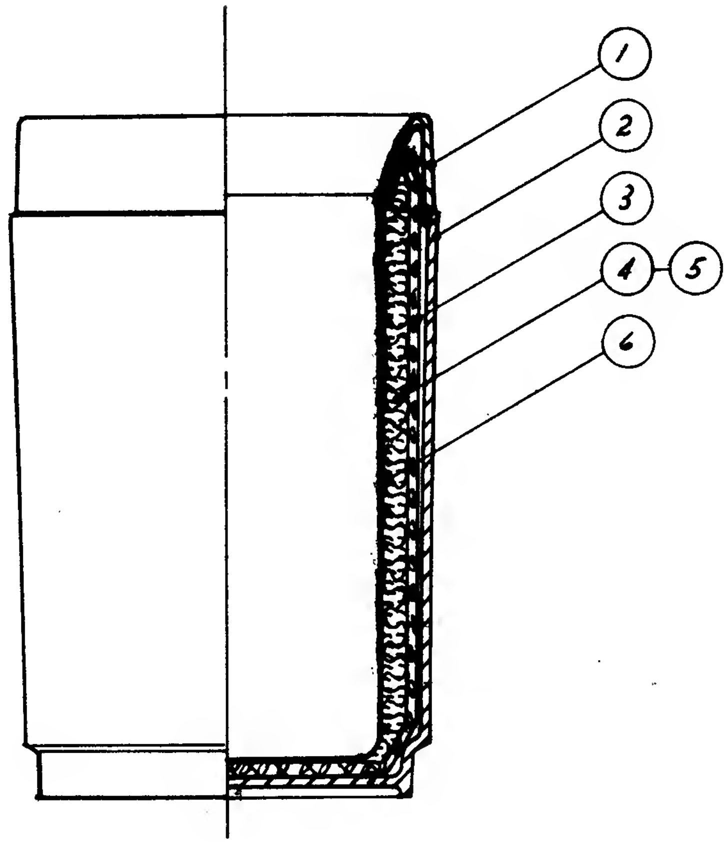
FIGURE 5

casting processes were being considered when it was suggested that the first prototype may have demonstrated a correct concept. This first prototype had used beer and soft drink cans for its environmental contact surfaces. An investigation of Alcoa aluminum's production of the new aluminum beer can showed promise. The Alcoa people have a great deal of experience in impact extruding cans of all sizes. When it was presented to them, all concerned felt that a suitable inner cup could be produced from existing standard dies. The aluminum cans had both the advantage of no tooling costs and the good conductivity of the very thin (.005 - .007 inch) aluminum. The inner surface could then be anodized to offer an attractive package.

A further innovation was possible for manufacturing purposes. The difficulties of assembly, sealing and durability could be aided by the construction of an inner cartridge. This cartridge could be formed of an inner 8 ounce beer can and outer 12 ounce can with the phase change material and conduction aid sandwiched between. This would form a clean package needing only outer insulation, decoration and a handle.

The next iteration in coupling was inspired by Chore Girl copper scrub pads. A designer noted the copper mesh had relatively low mass but very high surface area. The next prototype therefore utilized a copper mesh between inner and outer cups. When tested this scheme exhibited good performance. In addition a thin wire copper mesh was obtainable at a very reasonable cost as scrap. Thus at the end of one year's work Ryan's Enterprises had a prototype consisting of a thin inner cup formed in beer can dies, an outer insulating cup of turned nylon, beeswax for the phase change material and a copper wire mesh to improve coupling and conduction to the beeswax. A similar design is shown in Figures 6 and 7.

This prototype, while workable, did not seem to be optimum for several reasons. Reliably placing the wire mesh in intimate contact with the inner cup did not seem to be a process which could be efficiently integrated into a production line. The contact between copper and cup was mechanical and not entirely reliable. The beeswax itself was not optimum with its slightly high melting point of 155° and questionable steady supply in manufacturing quantity and quality. Finally, several problems had not been completely resolved. These included outer insulation and a durable sanitary joint between the inner aluminum cup or cartridge and the outer insulating cup.



PART	WT [illegible]	MAT'L	MFG	TOTAL
1 POLYPROPYLENE LIP MOLDED W/ HOUSING		SEE BELOW		
2 POLYPROPYLENE HOUSING		.0525	.0216	
.0525 wall thk.	56			.0741
3 STYREFOAM INSULATING CUP				
				.005
4 PARAFFIN WAX				
	60			.01
5 COPPER 'WOOL' .30/lb	28	.0187	.01	
(ALUMINUM 'WOOL') .15/lb	(14)	(.0047)		
				.0287 (.0147)
6 DRAWN ALUMINUM CUP ANODIZE		.06	.0325	
				.0925
				2103 (.1963)
ASSEMBLY:				
LOAD INSULATING CUP W/COPPER			.0159	
ADD PARAFFIN			.013	
INSERT ALUMINUM CUP/SPIN EDGE			.0172	
INSERT IN OUTER HOUSING			.005	
PUT LIP IN PLACE & WELD			.0138	
INSPECT			.01	
BOX			.015	
BOX			.009	
				.0979
15% LINE BALANCE				.0147
10% CONTINGENCY				.0308 (.0294)
				.3547 (.3383)

FIGURE 6

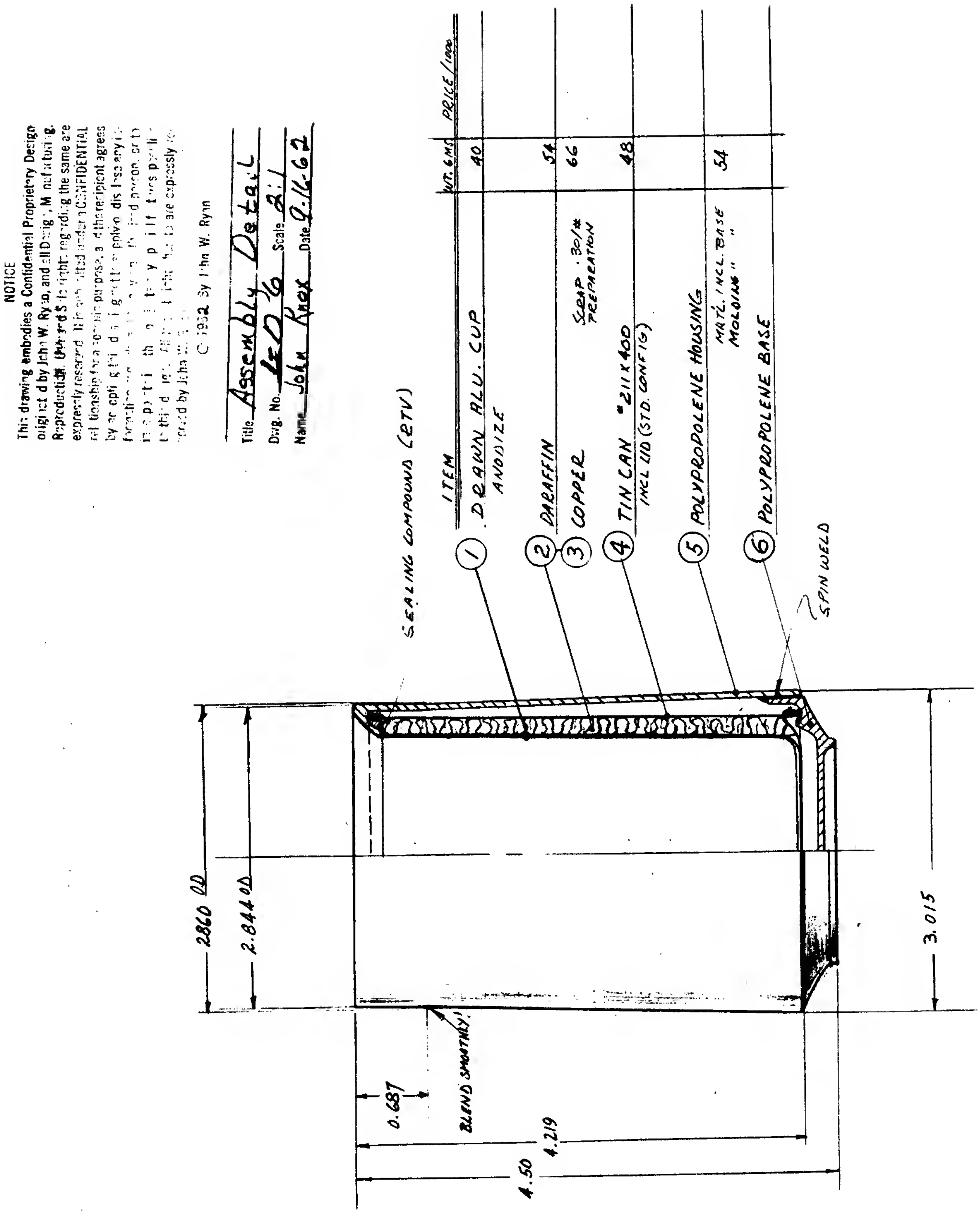

NOTICE
© 1962 By John W. Rynn
Title Assembly Detail
Name John Knox
Scale 2:1
Date 9-16-62
ITEM
WT. GMS
PRICE/1000
1 DRAWN ALU. CUP
ANODIZE
40
2 PARAFFIN
54
3 COPPER
SCRAP · 30/# PREPARATION
66
4 TIN CAN "211X400
INCL LID (STD. CONFIG)
48
5 POLYPROPOLENE HOUSING
MAT'L. INCL. BASE
54
6 POLYPROPOLENE BASE
MOLDING "
SEALING COMPOUND (RTV)
SPIN WELD
2860 OD
2.844 OD
3.015
0.687
BLEND SMOOTHLY!
4.219
4.50

FIGURE 7

Selling the Cup

Aware of interest in the cup, one of Mr. Ryan's patent attorneys offered his services in obtaining necessary patents in return for a percentage of the profit. This appealed to Mr. Ryan and he agreed.

While there were still many problems associated with the design, the single most significant problem was that of settling upon an appropriate manufacturing process for the cup. In order to interest prospective manufacturers, it was imperative that Ryan Enterprises have a reasonable cost analysis of the product as well as tooling information, lead times, and prospective vendors for the different components. Before this data could be developed it was necessary to solve some existing technical problems.

Thermal Coupling Problem

The materials employed up until this time were not wholly satisfactory, and the problem of providing a more suitable phase change material persisted. What was required was an inexpensive, non-toxic, readily available, lightweight material whose melting temperature could be fixed within a narrow, reliable range.

One day, Mr. Ryan learned that in the fractional distillation of crude oil it is possible to collect paraffins at discrete melting temperatures. Soon thereafter, Mr. Wally Shapero, a chemist working with Ryan Enterprises, was assigned the task of investigating paraffin as a phase change material for the Thermo-cup.

In analyzing the phase change problem, Mr. Shapero was concerned not only with obtaining a material which would melt at a preferred temperature, but one which would melt uniformly and transfer heat quickly throughout the medium. Since the inclusion of copper mesh as a means of transferring heat was successful in the beeswax prototype made in 1962, Mr. Shapero initially elected to use it in conjunction with a paraffin of suitable melting temperature.

Mr. Shapero chose a refined Chevron wax available from McKesson-Robbins. Prototype cups were constructed using the copper mesh paraffin combination and these proved successful. The 130° cup incorporated a mixture of paraffins having two distinct melting points: 75% of a 133°F - 135°F melting wax and 25% of a 160°F -165°F melting wax.

The 140° cup contained 143°F - 145°F refined wax. The reason that the melting temperatures of the constituent paraffins were higher than the nominal cup temperature was that there must exist a finite temperature gradient between the melted paraffin and the cooler coffee for heat to be transferred back into the coffee.

Although the paraffin-copper mesh combination worked satisfactorily, it was felt that because of the manufacturing problems a simpler, previously mentioned, less expensive means of transferring heat through the paraffin should be used. With this in mind, Mr. Shapero investigated the addition of conductive materials to the paraffin itself. He finally formulated the idea of mixing aluminum powder in with the paraffin. While this reduced the conductivity problem, the aluminum powder had a tendency to settle when the wax was in the liquid state. Also, the addition of too much aluminum interfered with the recrystallization process of the wax, and consequently reduced the cup's effectiveness.

Further research into the use of aluminum led Mr. Shapero to the combination of 45% by weight aluminum flakes and 55% by weight paraffin. The resulting mixture gave the desired phase change property: it melted quickly, and did not suffer adverse recrystallization effects. A limit of plus or minus 5% was placed on the aluminum content to insure a functional mixture.

Mechanical Coupling Problems

During the original design phase in 1962 the problem of obtaining a sanitary joint between the inner cup assembly and the outer shell had been considered. In the past, the method of joining utilized a room temperature vulcanizing (RTV) compound. This worked well, but unfortunately RTV was not suitable for manufactured products as it did not provide a sanitary seal.

Various new methods were suggested. It was thought that spin welding was a possibility. Spin welding entails holding the two parts together with moderately large forces and then rotating the two in opposite directions. Spin welding was an advanced state-of-the-art process at this time and Mr. Ryan was not sure of its applicability. Another scheme was that of making the cup like a standard vacuum bottle with a threaded seal. In this case a fastidious person could remove the seal and wash the interior section. Various cost and technical problems made these solutions appear impractical, so in 1968 the joining problem was still a major questionmark.

A ceramic outer cup was proposed. Such a design would necessitate a ceramic-to-metal seal of the type commonly used in the electronic components industry. Another proposal was a thin vacuum-formed plastic coating which separated the coffee from the inner aluminum cup. The advantage of this design was that the joining of the inner cartridge to the outer cup was greatly simplified. Figure 8 shows this idea. Unfortunately, the plastic coating greatly interfered with the heat conduction through the inner wall to the phase change material.

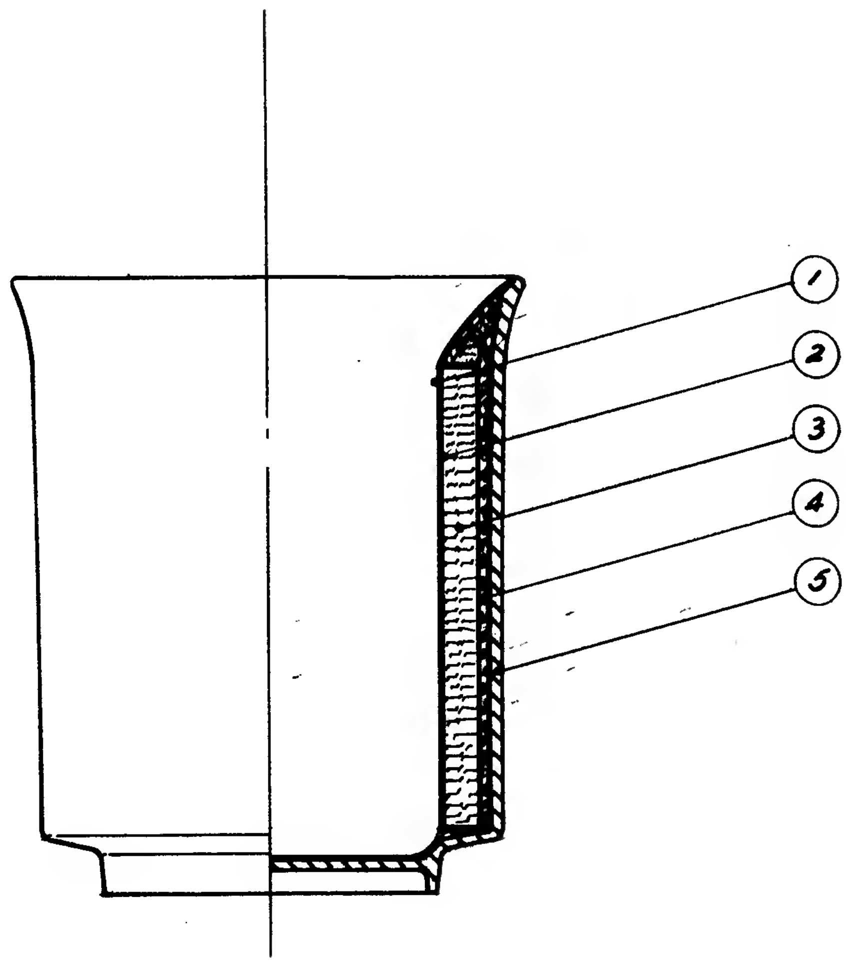
By spring 1968 the cup was still in the product design stage and as such the designers were primarily concerned with constructing a reliable product which performed well. Although the designers were aware of potential manufacturing problems back in the preliminary design stage, it was felt at Ryan Enterprises that the cup would have to undergo a manufacturing engineering stage prior to being considered for mass production. For this reason, it was decided to use an epoxy polysulphide compound as an interim measure for the seal between the inner cup and the outer shell. This method worked satisfactorily.

Additional Problems

While there did not seem to be too much trouble in filling the metal cartridge with the heat storage material during the fabrication of a prototype, there was not a clear cut method of doing so in production. It was observed that if voids were present in the cartridge during the solidification process, the paraffin would move away from the inner cup leaving an annular void adjacent to the inner cup. As a result, the necessary thermal interface between the coffee and the paraffin was destroyed. Whatever manufacturing process was chosen had to guarantee that the cartridge was satisfactorily filled before sealing.

Since the paraffin expands during heating and contracts as it solidifies, the problem of bursting was present. It was necessary to design the cartridge seal in such a way that the thermal and mechanical stresses would not degrade the joint, and to provide sufficient room between the cartridge and the outer shell for radial expansion.

The material to be used for the cup's exterior was still uncertain, with several possibilities under consideration. Among these were plastics and ceramics. The idea of making cups with metal exteriors, thereby eliminating the sealing problems, was considered, but it was rejected for two reasons.



1	VACUUM FORMED LINER (.08 MATL.) HEAT SEAL	.04
2	EXTRUSION	.127
3	PARAFFIN	.0154
4	STYRAFOAM INSULATION	.005
5	POLYPRODOLENE HOUSING	.057
	ASSEMBLE	.444 .0325
	TOTAL:	.2769

FIGURE 8

First, too much heat would be conducted to the outer shell and hence lost. Second, the outer shell could become excessively hot and possibly burn a person's lips.

An additional problem that required attention was that of insulating the inner cartridge from the outer cup or shell. A variety of materials and configurations was tested. Among those considered were tissue paper and tin foil, tissue paper alone, insulation paper, cotton and tin foil, styrofoam, and felt. Of all the materials tested, .040 felt insulation proved to be the best compromise from a functional and economic standpoint.

Product Design Configuration

Despite the manufacturing problems encountered by Mr. Ryan, the Thermo-cup was developed into a workable product design. By spring 1968 the design consisted of basically three components: the cartridge, the phase change material, and the exterior cup.

The cartridge, shown in Figure 9, was constructed of an 8 ounce aluminum beer can crimped inside a larger 12 ounce beer can. The only place that the interior cup came in contact with the larger can was at the mechanical joint on top.

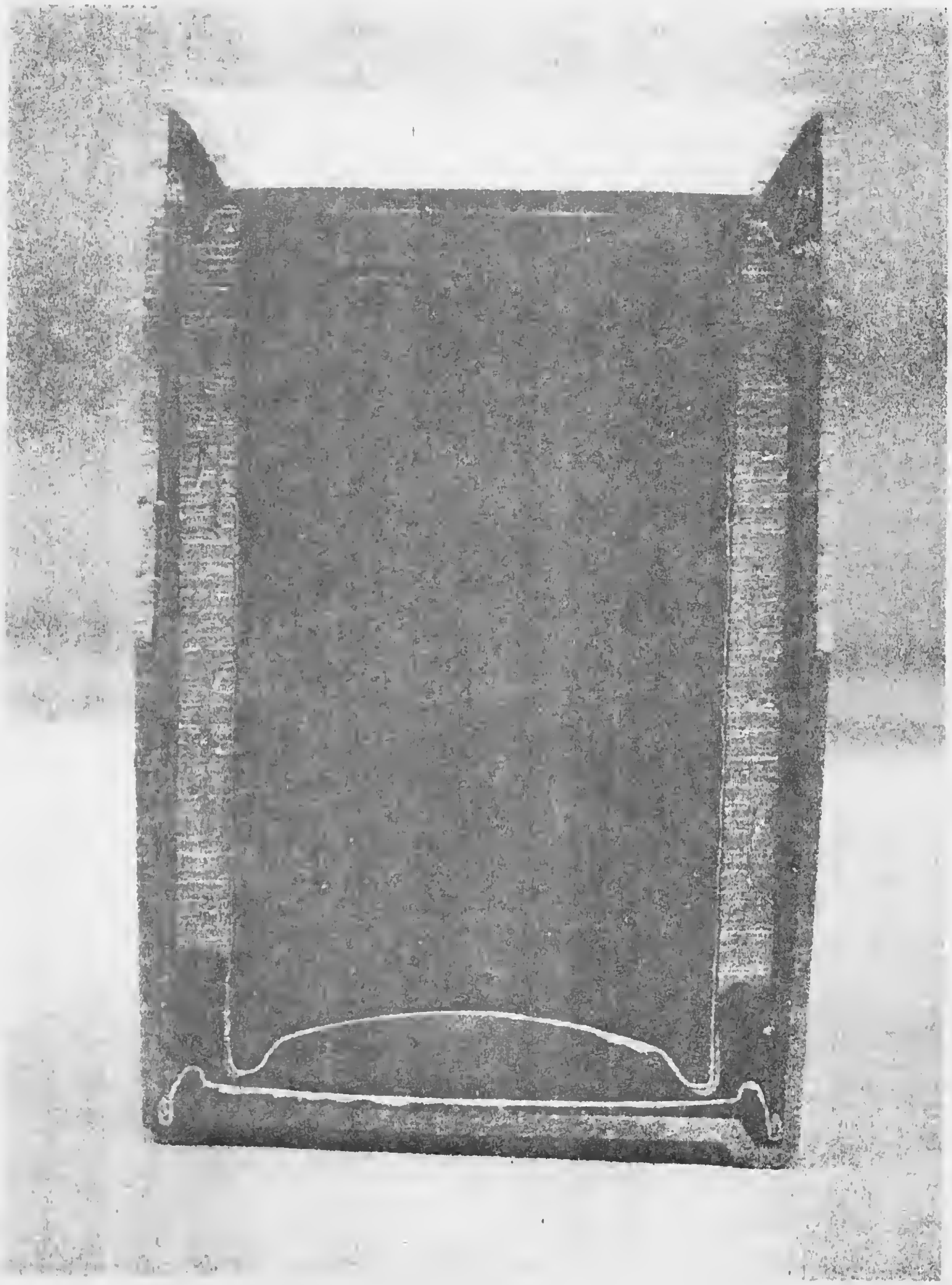
The phase change material, paraffin and aluminum flakes, were poured into the cup and the center void filled. Figure 9 shows approximately 20% void space at the bottom; however this was strictly a demonstration model.

The external cup was fabricated from three pieces of plastic; a handle and upper and lower halves. It is apparent from Figure 10 that the two seals, the mechanical cartridge seal and the sanitary seal between exterior cup and cartridge, are in close proximity. The .040 felt insulation was employed to insulate the two cup assemblies as shown in the two exhibits. Figure 10 displays the Ryan cup in its final product design form.

Cost Analysis

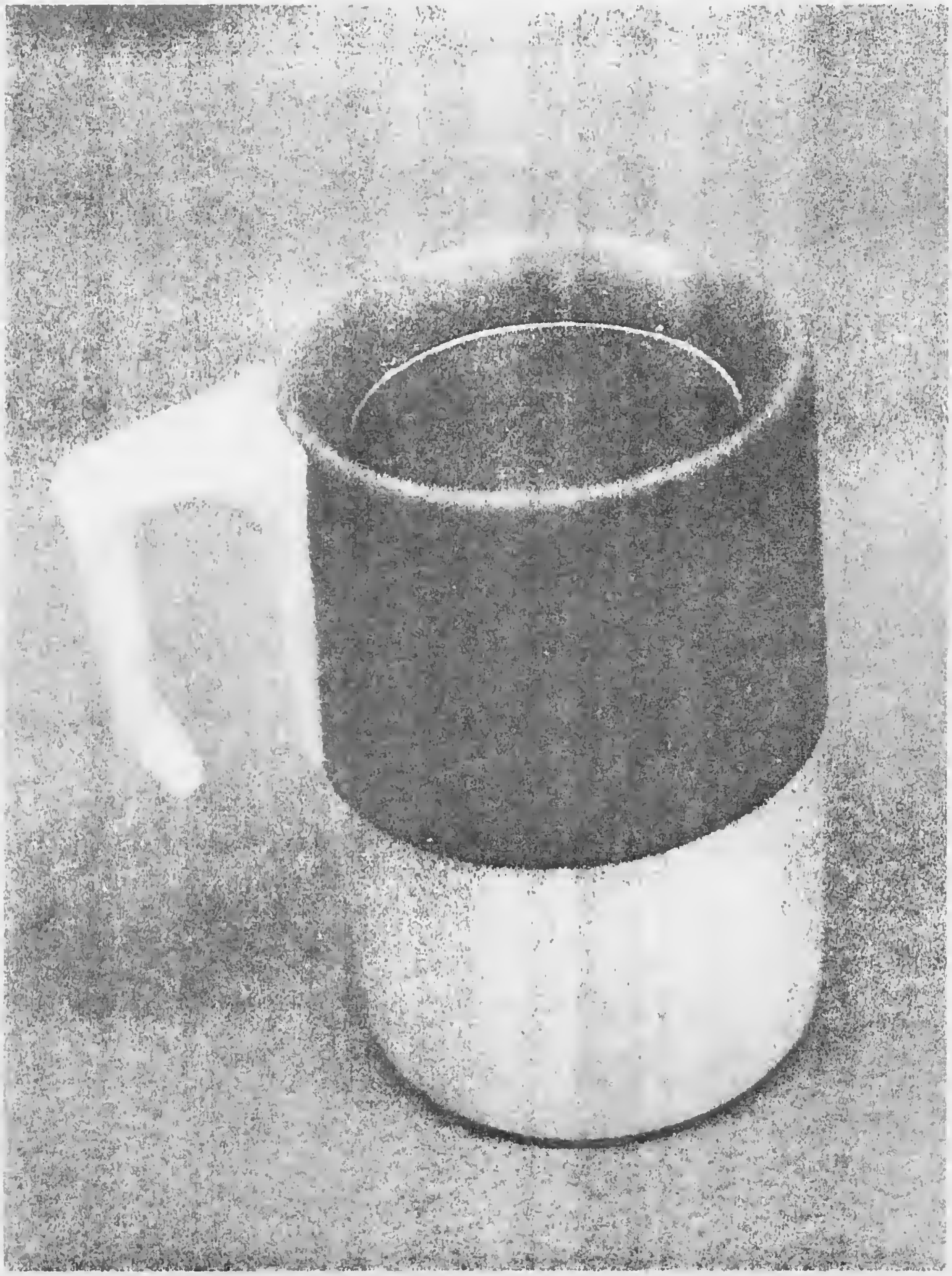
During June 1968 a preliminary cost analysis of the Thermo-cup was made in anticipation of presenting the product to potential manufacturers. At this time there were two main choices for the external cup material; plastic and ceramic.

The first was to be made of glass-filled ABS plastic or suitable equivalent. The reasons for choosing plastic were cost



Cross-Sectional View of Isothermal Cup

FIGURE 9



Product Design Form of Isothermal Cup

FIGURE 10

and the availability of materials, ease in production, and the public acceptance of plastic as a houseware material. The ceramic cup was not intended for as general a use as the plastic version. Instead, being a little more exotic, it was aimed at the gift market. The ceramic material could vary from plain earthenware to china with decal decorations.

Since the eventual tooling cost would vary somewhat depending upon the quantities involved and the final design, it was difficult to put a fixed cost on that expenditure. Depending on whether the cups were domestic or foreign, the price could vary substantially. United States prices were estimated to be as much as 300% higher on custom made parts than the Japanese prices. However, the ceramic cup tooling was tentatively estimated at $2,500 based on a production rate of 4,000 units per day.

The material cost of the plastic cup and base was thought to be $90 per thousand while an earthenware ceramic cup was set at $500 per thousand. The fancier china cup with decorations was $2,000 per thousand.

Table 1 gives a breakdown of the remaining cost analysis. Since it was estimated that different versions of the ceramic cup and base would run anywhere from $0.50 to $2.00 per cup, depending upon material and looks, Mr. Ryan settled upon $.70 as a reasonable price for the ceramic cup. He felt that a modest ceramic cup would sell better than the higher priced version. Combining the $.70 for the exterior, $.397 for raw materials and manufacturing and a 10% contingency cost to cover unexpected expenses a price of $1.21 for the ceramic cup was determined. The plastic model was set at $.54 which included the same 10% contingency allowance.

Having established a minimum cost level for the cup, Mr. Ryan next considered the question of what the selling price should be.

Based on accepted marketing procedures, Mr. Ryan concluded that the cup would be sold for between $2.99 and $3.99. This price would leave sufficient margin for profit after the manufacturer's overhead, retailer's markup, advertising costs, and the material costs were met.

Presentation of the Isothermal Cup

In early 1960, Ryan Enterprises initiated a patent search to determine the patentability of a part or all of the latest cup design. One result of an earlier search was the discovery

TABLE 1

ISOTHERMAL CUP COST ESTIMATE

Item or Process	Cost Per Thousand Units
Inner aluminum cup	\$80.00
$6\frac{1}{2}$ oz. anodized, optional	\$35.00
Aluminum of tin plate outer cup	\$40.00
Top closure to join both metal cups	\$10.00
Join top closure to cups	\$20.00
Join bottom closure	\$10.00
Heat storage medium 120 gm, 45% Al	\$127.00
Mixing of heat storage medium	\$15.00
Fill cartridge with heat storage material	\$20.00
Bond metal cartridge to cup	\$30.00
Bond base of cup to upper with expansion pad	\$10.00
	\$397.00

Ceramic: \$.70 + \$.397 + 10% contingency = \$1.21/each

Plastic: \$.09 + \$.397 + 10% contingency = \$.54/each

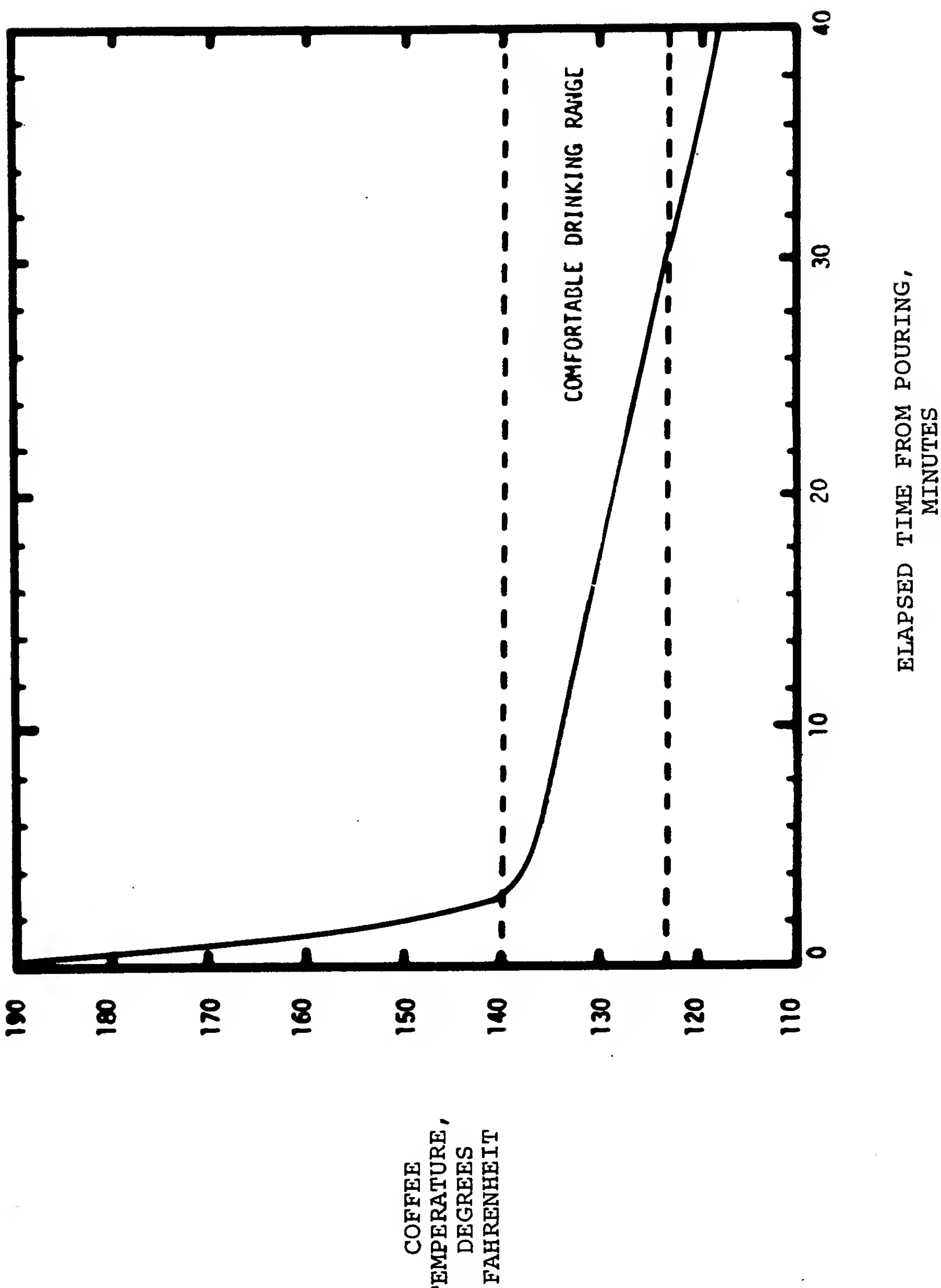
of a patent by H. G. Zimmerman. Concerned that this patent might in some way conflict with one of the variations of construction which they might use, Ryan Enterprises bought the patent outright. In March 1969 they applied to the United States Patent Office for a patent on the cup, under the title Thermodynamic Container. The patent has been issued and is included as an Appendix. Ryan Enterprises now felt that they had the Thermo-cup sufficiently well designed to present to possible manufacturers.

Mr. Gilbert Thomas, for the last several years, had been a Vice President of Ryan Enterprises. After receiving his Bachelor's degree in Psychology and MBA from Long Beach State College, he became involved in the business and marketing aspects of numerous products.

Mr. Thomas was in charge of the marketing phase of the Thermo-cup project. In the spring of 1969 he contacted 10 major houseware manufacturers both in the United States and in Europe in hopes of presenting and selling the Thermo-cup idea. Exhibit 1 is a typical example of the introductory letter sent by Mr. Thomas to a prospective company. In presenting the invention he related the outstanding features of the cup and included Figure 11.

One of the first major companies approached was Rubbermaid Corporation. On April 2, 1969, Mr. Thomas met with the new Sales Development manager of Rubbermaid, Mr. Moyer Smith. The Thermo-cup idea was so well received after his presentation that it was given top priority on Rubbermaid's New Products list. However, in the middle of April, during Rubbermaid's New Products Conference, it was decided to forego the cup at that time. The motivation for the decision was not entirely clear but it was felt that potential manufacturing difficulties were a factor and that the cup was outside their usual price range. The majority of Rubbermaid's product line sold for between 50 cents and a dollar.

The Thermos Company was the next manufacturer Mr. Thomas contacted. While the Regional Sales manager was personally sold on the idea it was later turned down. The letter of April 24, 1969 from Thermos to Ryan Enterprises seen in Exhibit 2 implies that they were leery of being able to develop sufficiently large profit margin to make the project worthwhile. Mr. Thomas commented later that Thermos, although a quite successful company, was a little too conservative and felt it was this conservatism which defeated the cup.



Temperature History of Coffee in the Isothermal Cup

FIGURE 11

Salton Incorporated, the manufacturers of Hottable and Hotray products, the David Douglas Company in Wisconsin, and McGregor of Milwaukee, a manufacturer of insulated products, all rejected the invention.

Mr. Thomas next chose the Ronson Company, an aggressive firm which manufactures a wide variety of household products. After the initial introduction, Ronson management was so impressed with the product that they invested five thousand dollars of their own money to have Ronson engineers look into the problems of manufacturing the cup. Specifically, they were concerned with methods of sealing the inner cartridge to the outer cup and with the cup's ability to withstand repeated washings in a dishwasher. After reviewing the results of the investigation, Ronson declined.

On 25 June 1969 Nibot Corporation advised Ryan Enterprises that they were not interested in the invention at that time and less than a month later Cory Corporation returned a similar reply. In answering, Cory brought out the basic reason why the various manufacturers were not interested in the cup. In his letter of August 19, 1969, N. H. Schlegel, Vice President of Marketing, stated that if and when a final design was achieved Cory would be happy to reconsider the offer. It was apparent at this point that the major houseware manufacturers in the United States were less than anxious to complete the manufacturing design themselves.

By the fall of 1969, after having little success in the United States, Mr. Thomas decided to consider possible European manufacturers. As a preliminary step he began in late October the application procedure for foreign patents on the Thermodynamic Container in the United Kingdom, France, Ireland, Sweden, Italy, Japan, Switzerland, Canada, the Netherlands, the Union of South Africa, as well as West Germany.

Mr. Thomas next began correspondence with Melitta-Werke-Bentz und Sohns, a large German housewares manufacturer with a world-wide reputation for silver products. Their annual sales were over $125 million. Unlike Ronson or Thermos in the United States, who display their products in large department stores, Melitta owned their own retail store outlets.

Rather than dealing directly with Melitta, Mr. Thomas chose to engage another German business, Canores, as Ryan Enterprises European agent in locating a possible licensee for the Thermo-cup. The rationale for doing so was that a German company could better understand the European market

and it freed Mr. Thomas from otherwise frequent trips to Europe. Also, Canores was representing several other Ryan Enterprises products, specifically, their Microwood line and this simplified matters. Exhibit 3 is Mr. Thomas' letter to Mr. Dettmer of Melitta in which he spells out the terms of various licensing schemes.

The Thermo-cup idea was very appealing to the Melitta Company and they even came up with some additional uses for the invention. Melitta envisioned the phase change concept being used in the production of cups, plates, and for food warming trays for use in hospitals, convalescent homes, and other institutions where large quantities of food are prepared. Also, containers for infants' food was another possible product line.

Melitta was understandably interested as they had been working in the same area but were not successful. They wanted as many details of the cup as possible and expressed this desire to Canores. Before confidential ideas are presented, normally both the inventor and the manufacturer agree on certain disclosure guidelines. This was done in the case of the Ronson Company prior to their investigation of the Thermo-cup. Whether Melitta was overanxious to see the details or they just did not appreciate Mr. Ryan's desire to have a reasonable protection for his idea, was not clear. In his tersely worded letter of November 4, 1969, Mr. Thomas explained to Melitta that Ryan Enterprises would not go into details of the cup's construction without a properly signed disclosure form. His letter is shown in Exhibit 4.

Melitta finally agreed to the disclosure idea and was given confidential information on the Thermo-cup. They experimented with the product for over half a year. During this time there was a great deal of communication between Ryan Enterprises, Canores, and Melitta.

On April 2, 1970, Melitta officially declined Ryan Enterprises' offer for an exclusive license to manufacture the Thermo-cup but did request that they maintain contact with Mr. Ryan. A translated copy of their decision is shown in Exhibit 5.

Melitta was unable to pursue the cup idea for slightly different reasons from the United States manufacturers. While they were concerned about ironing out the manufacturing difficulties, other company problems kept them from accepting an exclusive license. For many years prior, Melitta had been expanding throughout Europe and when the economic slump hit

in the late sixties, Melitta found themselves overextended. As a result, their management put the project on the "back burner" until such time as they could financially justify it.

Present State of Affairs

In spite of the failure to find a company interested in producing the cup, Mr. Thomas was encouraged by the number of people who expressed enthusiasm for the idea. It was obvious that there was a demand for such a product.

MANUFACTURING DESIGN

In early April 1971, Jack Ryan learned that his United States patent had been allowed and would be issued within 60 to 90 days. Ryan Enterprises now had a decision to make. Should they scrap the project, put it on the shelf, or do the manufacturing engineering themselves?

Shortly thereafter, Mr. Harvey LaBranche, an engineer who once worked at Ryan Enterprises, but had moved to Seattle, Washington, approached Mr. Ryan and asked if there were a job he could tackle until he was settled. Mr. LaBranche was given the task of doing the manufacturing engineering on the Thermo-cup. Specifically he was requested to propose a definite method of cartridge-to-outer cup joining, a method of filling the cartridge, cup materials, overall manufacturing procedures, and a detailed cost analysis for tooling and material prices for the cup.

As mentioned earlier, Jack Ryan's personal design philosophy consists of four major steps: feasibility studies, preliminary, product, and manufacturing designs. Over the years Ryan Enterprises has become successful by carrying an idea from the initial conception through the product design stage. Rather than produce and market the product themselves, they eliminate large overheads and marketing headaches by licensing their product designs to other manufacturers. Their success, of course, is contingent upon being able to find interested buyers.

Unfortunately, as Mr. Ryan found out, many companies are unwilling to buy a product design which requires additional work. As he remarked, "you may have a nifty idea, but unless it is ready to manufacture not too many companies will buy it."

GILBERT A. THOMAS
MANAGEMENT CONSULTANT
Specializing in the Management of Creative People

[redacted] 14711 Mimosa Lane
TUSTIN, CALIF. 92680 (714) 544-5362

June 6, 1969

Nibot Corporation
3600 West Pratt Avenue
Chicago, Illinois 60645

Attn: G. Gigstad:

Dear Mrs. Gigstad:

I enclose two signed copies of your disclosure agreement. This agreement has been signed by John W. Ryan the owner and inventor of the coffee cup.

Mr Ryans invention, for which a patent application has been filed, utilizes the property of certain materials to absorb or give up many calories of heat when they change states, ie, undergo a phase change. Certain safe, low cost materials have been selected and constructed into a cup which has the following distinctive features as compared to an ordinary coffee cup and a thermo-cup, ie, an insulated cup.

	Ordinary Cup	Thermo Cup	Ryan Cup
Original temperature of coffee, tea, etc.	190°	190°	190°
Temperature after 3 minutes	170°	185°	140°
Temperature after 7 minutes	140°	165°	137°
Temperature after 12 minutes	124°	150°	134°
Temperature after 19 minutes	less than 100°	140°	130°

EXHIBIT 1

	Ordinary Cup	Thermo Cup	Ryan Cup
Temperature after 30 minutes	Ambiant	129°	124°
Temperature after 35 minutes	Ambiant	124°	120°

Our studies have indicated that the average individual can enjoy hot beverages in the 140° to the 124° range. The regular coffee cup requires one to wait seven minutes while the liquid cools to a drinkable temperature then one must consume it in five minutes or it is too cool to drink.

Hot liquid poured in a thermo cup takes nineteen minutes to cool down to drinkable temperatures then remains in the comfortable range for 16 minutes. The Ryan cup lowers the temperature of liquid poured into it to the drinkable range in three minutes and keeps the liquid in that range for 30 minutes.

This cup can be produced in either a plastic or ceramic version. With the proper promotion we feel that a significant volume of Ryan cups can be sold both in gift and houseware departments across the country. We are looking for a progressive company who can handle this item on an exclusive basis and do a proper job of marketing and promotion.

I plan to be back East in the latter half of June and would like to arrange a meeting with the proper persons in your company to show actual models of the cup and answer any detailed questions that may arise.

Sincerely,

Gilbert A. Thomas

Gilbert A. Thomas

GAT/pt

EXHIBIT 1

THERMOS DIVISION
NORWICH, CONN. 06360

OFFICE OF
ROBERT C. SLYDER
VICE PRESIDENT - MARKETING

KING-SEELEY KST THERMOS CO.

April 24, 1969

Mr. Gilbert A. Thomas
Ryan Enterprises, Incorporated
674 Nimes Road
Los Angeles, California 90024

Dear Mr. Thomas:

Our Marketing Staff have reviewed the information which you sent and also the comments forwarded to our Mr. Tom Hemp in Chicago regarding the special insulated cup developed by Mr. John Ryan.

While the idea is novel and definitely does have merit, we felt that the volume of product that we could move wouldn't be sufficient to absorb the various costs and still provide us with a reasonable profit.

We appreciate your submitting the idea to us, and hope that you will keep us in mind on any future developments which might be within our area of operation. While admittedly any sales projection we would make on a brand new idea like this is to a large amount guess work, it just didn't seem that we could sell enough to get the cost price per unit where it should be.

Sincerely yours,

Robert C. Slyder

Robert C. Slyder

RCS:MK

EXHIBIT 2

September 22, 1969

Mr. Dettmer, Managing Director
Melitta-Werke

Dear Mr. Dettmer:

I am sending you this letter through my good friends Mr. Urla and Mr. Lang of Canores who have introduced you to the Thermo-Cup.

This cup has the excellent properties that they have demonstrated to you. It can be manufactured in a variety of configurations with either plastic or ceramic on the outside and any number of different metals for the inside.

We are quite flexible as far as licensing arrangements are concerned. I would suggest three possible arrangements and there are a number of possible variations of these. These arrangements are in outline form; the details we can work out as we develop our business relationship.

1. Exclusive manufacture and distribution for continental Europe, excluding the United Kingdom. This would be granted for a payment of $6,000.00 cash and a 6% royalty on the net sales of all products using the cup construction principles.

2. Exclusive manufacturing and distribution rights for all of Europe, Africa and Asia and the Islands of the Pacific (excluding North and South America). This would be granted for a payment of $15,000.00 plus 6% royalty on net sales of all products utilizing the cup construction principles.

3. Exclusive manufacturing and distribution rights for the entire world. This would be granted for a payment of $30,000.00 cash plus 6% royalty on the net sales of all products utilizing the cup principle.

Net sales is your selling price less discounts and returns.

We are currently negotiating with several U.S. companies for the exclusive world wide manufacturing and marketing license. Until we sign a final agreement however, your opportunities for obtaining such a license are as good as any one elses.

EXHIBIT 3

September 22, 1969

The Cory Corporation, best known as makers of coffee machines, had been considering the Thermo Cup but has recently declined the exclusive manufacturing and marketing proposal. They are still interested in handling the U.S. marketing of the product however, if the price is right.

I am enclosing a copy of their letter to assist you in your planning.

If you do not have a distribution outlet for the U.S. you could perhaps manufacture in Europe and distribute in the U.S. through Cory; that is if you decided Melitta could handle the world wide arrangement.

If you are interested in pursuing this matter further I can fly to Europe at very short notice to discuss all details with you.

We are asking any company outside of the continental United States to share the costs of my trip by paying 50% of the round trip airfare from Los Angeles to their location as an expression of the level of their interest in our product. In the case of Duesseldorf the round trip airfare from Los Angeles is $794.00. Fifty percent of this would be $397.00.

Upon receipt of your written agreement to share the airfare to Europe I could be in Dusseldorf within a week to 10 days to discuss this matter further with you.

Sincerely,

Gilbert A. Thomas

Enc.

EXHIBIT 3

November 4, 1969

Meletta-Werke
Bentz & Son
ATTN: Mr. Dettmer
495 Minden (Westf.)

Dear Mr. Dettmer:

I received your letter in which you mentioned that Mr. Wiedemann would contact me in the near future concerning the Thermo Container. I will be very pleased to meet him and discuss in general the Thermo Container and our possible business relationship. However, I feel that I cannot go into details of our construction until I receive a copy of the disclosure form properly signed by an authorized person in Melitta-Werke.

As you know Mr. Dettmer, there is often a time lag of two to three years from the filing of a patent application to the issuance of that patent. During that period we have no protection for our ideas. The patent, when issued, gives us the negative right to prevent others from making, using or selling our device. During the period that the Patent Office is processing the application we have no such right.

All we ask in our disclosure form is that if we give you full and complete information concerning our device you will agree not to use that information to produce any products using those principles without taking a license from us and will not disclose the information to another party.

It would not be fair for us to give you the knowledge we have gained through two and a half years of research and the expenditure of nearly $40,000.00 without having your agreement not to disclose our secrets or use them without taking a license. I am sure you are not proposing to do either but the disclosure form we presented to you is the only legal protection we have until the patent is issued.

Our patent was applied for in the United States in March 1969. Following the rules of the Paris Union International Convention for the Protection of Industrial Property we have filed our applications in fifteen other countries subsequent to our U.S. filing.

You will be obtaining the information which is now secret well ahead of any other company in Europe. Your economic advantage if you choose to market a line of products constructed along the principles of the Thermo Container will be great.

EXHIBIT 4

November 4,1969

This advantage will enable Melitta-Werke to reap the benefits of being first on the market with a completely new product and being able to maintain its position as exclusive manufacturer of that product for a long period of time before competitive companies must also be given a license to produce similar products.

We are quite willing to cooperate fully with you and assist you in any way we can to gain full knowledge of the principles of the Thermo Container and to quickly get into production of a line of products. All we ask is an assurance that our economic and time investment will not be lost. The disclosure form is our legal protection against such loss.

Concerning the reports which you received regarding similar products, I am sure when you see samples of what is on the market you will see the advantage of our product. Nothing being marketed anywhere in the world will do what our device will do. We keep a close watch on the market and know what is currently being sold.

I hope you will receive this letter in the spirit in which it is written. We want to honestly and fairly deal with you and if you so choose, to assist you in every way to produce a profitable line of products utilizing the Thermodynamic Container principles. Your success is also our success.

I am sending this letter through Canores GmbH of which my good friends Messers. Urla and Lang are the principals.

We rely upon them to represent us in Europe and to protect our interests in this and future new product ideas which we are currently developing.

Sincerely,

Gilbert A. Thomas

EXHIBIT 4

TRANSLATION

MELITTA - WERKE
BENTZ & SOHN

4950 Minden (Westf.)
the 2th of april 1970
Dt / Klp

Management

Company
C a n o r e s
Vertriebs-GmbH.

4000 Düsseldorf

Kasernenstraße 23

Thermodynamic Container, relating to project from the USA

Dear Sirs ,

after a long absence of our Mr. Horst BENTZ, we were today able to talk with him concerning your proposed thermodynamic project.

We wish to confirm to you, that the idea to keep warm, on a different principle as until now employed, interests us very much. We have with different isotherm containers as with isotherm cups, as that's usual in Italy, many experiences tried. The result is, that your cup at first loses much of warm temperature, afterwards the warm spending is remarkable. After 30 minutes it is seen, that your container holds more the warm temperature than any other containers of this kind.

We have much discussed for what kind of articles we can use your american method. Our experiences show on our thermo pots, that there are 2 alternatives: To make a thermo-pot woich holds all night the drink warm until the next morning; Or to make a thermo-pot which holds the warm temperature 1/2 to 1 hour, as normally usual.

For this case we have a new warm-hold-plate, who guarantees it with our glass-holders.

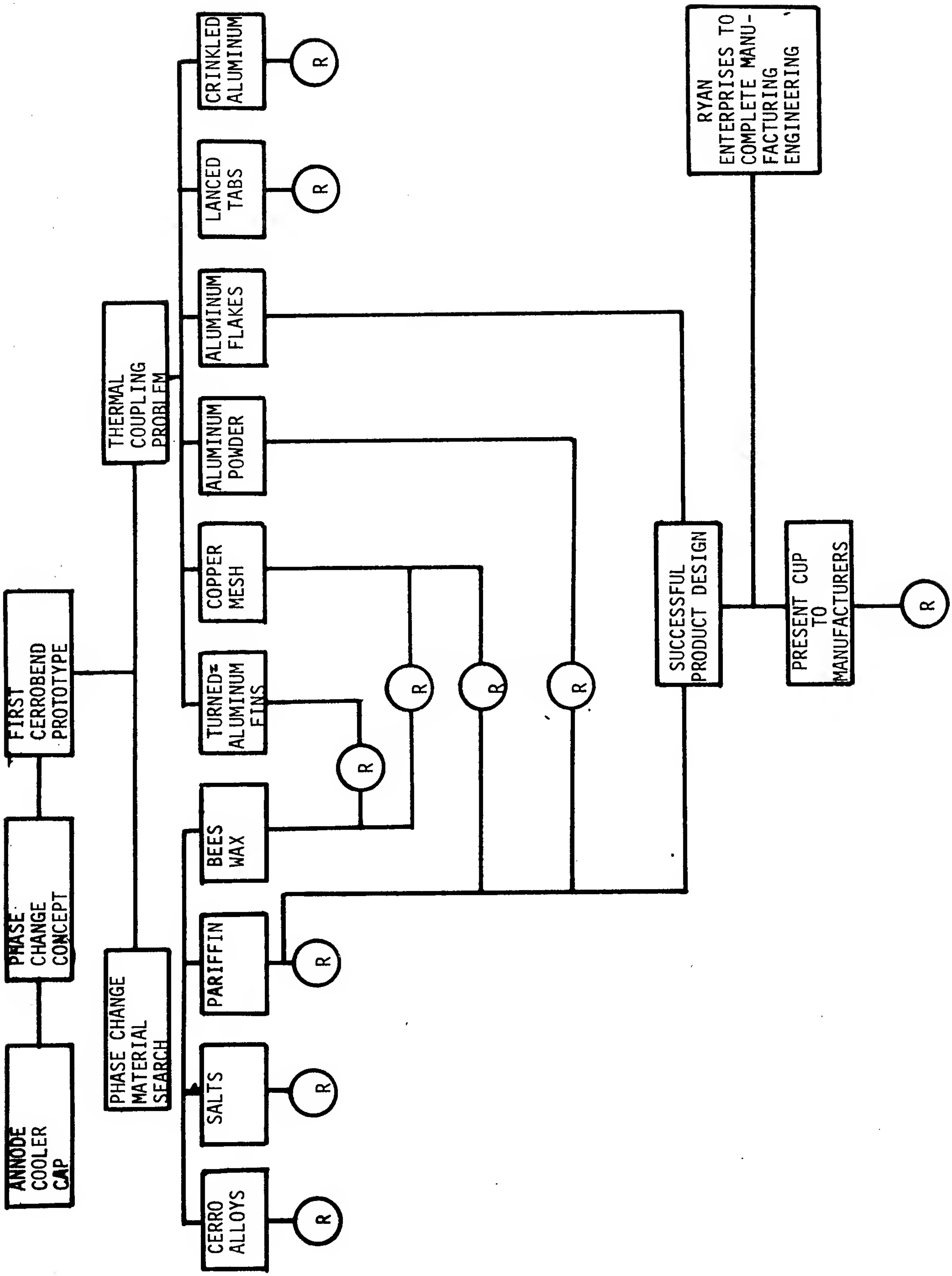
Our Mr. Bentz has decided, that we are not further interested on your American patent and please understand our decision.

When you get today the negative answer from us, we would specially remark, that we are very much interested to stay in best contact with you.

In a sense the Isothermal Cup Project is a first for Ryan Enterprises. They have resolved to break tradition and complete the manufacturing design themselves. Mr. Harvey LaBranche is presently working on a method of manufacture. He is also attempting to establish an accurate cost analysis for tooling and materials. Once completed, Mr. Ryan feels the Thermo-cup will be ready license and sell.

EXHIBIT 5

APPENDIX



ANNODE COOLER CAP
PHASE CHANGE CONCEPT
FIRST CERROBEND PROTOTYPE
PHASE CHANGE MATERIAL SEARCH
THERMAL COUPLING PROBLEM
CERRO ALLOYS
SALTS
PARIFFIN
BEES WAX
TURNED ALUMINUM FINS
COPPER MESH
ALUMINUM POWDER
ALUMINUM FLAKES
LANCED TABS
CRINKLED ALUMINUM
R
SUCCESSFUL PRODUCT DESIGN
PRESENT CUP TO MANUFACTURERS
RYAN ENTERPRISES TO COMPLETE MANU- FACTURING ENGINEERING

THERMODYNAMIC CONTAINER

SUMMARY OF THE INVENTION

This invention relates to food and beverage containers particularly adapted for controlling the temperature of beverages therein, especially coffee, tea and the like.

One of the great troubles found by drinkers of hot beverages, such as coffee, is the wait for the coffee to cool to a drinkable temperature. Commuters in a hurry and others who may not be able to wait for the beverage to cool run the risk of burning themselves if they drink the beverage before it has cooled to a drinkable temperature. On the other hand, maintaining the beverage at a drinkable temperature is also a problem, especially for those who add cream and sugar to their coffee, for each time their coffee is warmed with fresh coffee, they must repeat the process of adjusting the mixture to their taste by adding more cream and sugar.

The teaching of H.G. Zimmerman et al. in U.S. Pat. No. 2,876,634 for a "Thermodynamic Container," was directed to the solution of these problems. This disclosure illustrated a coffee cup having a heat-storage material between its walls that absorbed heat from hot coffee poured into the cup. Beeswax was selected as the heat-storage material for its melting point of 147° F. was near the preferred drinking temperature of coffee. This material was capable of storing 45 additional calories of heat per gram because of its latent heat of fusion. Hot coffee above 147° F. melts the beeswax, thereby cooling the coffee until its temperature falls below 147° F. at which time the heat stored in the melted beeswax, as its latent heat of fusion, returns to the coffee keeping its temperature near 147° F. for an extended period.

As the coffee begins to cool by radiation, conduction and convection, its temperature falls below 147° F. causing heat stored in the liquefied beeswax, principally as its latent heat of fusion, to be released back to the coffee. In this way, the coffee will be kept at a drinkable temperature near the melting point of the beeswax for a longer time than usual.

Considerable research and experimentation in the development of this invention resulted in a more perfect means than shown in the prior art of rapidly conducting the heat from the hot beverage to the storage material, dispersing it rapidly through the storage material and holding it for return to the beverage as the beverage cools.

An object of the present invention is to provide a construction of materials which lend themselves more readily to mass production.

A further object of this invention is to provide a more adequate means for holding the heat-storage material so as to prevent the heat from escaping through the outside walls of the container.

Another object of this invention is to discover a selection of suitable heat-storage materials to adapt the thermodynamic container for cooling foods and beverages to a variety of preselected temperature ranges.

And still a further object of this invention is to provide an adhesive bonding which would provide the necessary flexibility to allow for the different coefficients of expansion of the components of this invention.

Attainment of these objects and solution of other problems inherent in Zimmerman's disclosure in U.S. Pat. No. 2,876,634 and in my own disclosure for "Temperature Retaining Means," in the now abandoned u.S. Pat. application, Ser. No. 141,814, are to be found in the present invention in the novel inclusion of a metal capsule as the means for holding the heat-storage substance. This capsule is fully insulated from the outer shell, which is attached to the metal capsule by a flexible adhesive.

Further objects and advantages of the invention will become apparent from the following detailed description and annexed drawings, wherein:

FIG. 1 is a perspective view of a preferred embodiment of the invention;

FIG. 2 is a sectional view of the invention illustrated in FIG. 1 taken along line 2—2; and FIG. 3 is a cutaway sectional view to illustrate the flexible adhesive attachment between the outer shell and the inner capsule.

Referring more specifically to the drawings, the numeral **10** is used to designate the preferred embodiment illustrated in FIGS. **1** and **2**. The inner metal capsule **12** has an inner wall **14** and an outer wall **16** which may be joined by "double-fold" seaming on a conventional can-closing machine. It is also possible, however, to join the walls of the metal capsule **12** by cementing, soldering or sealing with plastic sealants. The inner wall **14** of the capsule is an impact-extruded seamless aluminum beer can about 0.008 of an inch thick, anodized to give a more attractive appearance. The outer wall **16** of the capsule is a conventional can body about 0.015 of an inch thick. Any metal can be used that is sturdy enough for physical handling, but commercially practical selections would be aluminum or steel.

Although the inner capsule **12** is of double-walled construction in this embodiment of the invention, it can also be made in three pieces prior to assembly. If it is desirable for cost reasons, one, two or three different metals can be used; however, replacement of metal by plastic or other nonmetallic material does not prove satisfactory.

Since the inner wall **14** is the surface which is in contact with the beverage or food, replacement of the outer wall **16** was thought possible. It was found, however, that a totally metal capsule functioned slightly faster than one having only a metal inner wall, for in order to achieve fast cooling to the desired temperature range, the materials chosen for both the inner and outer walls of the metal capsule had to have a low specific heat and high thermal conductivity. The conductivity of the capsule **12** is greater than the intended food or beverage placed inside the finished container in order not to limit the rate of heat conduction between the food or beverage and the heat storage material **18**.

The mass of the capsule **12** is kept to a minimum to prevent creating a heat sink between room temperature and the selected temperature range of the metal capsule.

The heat storage material **18** between the walls of the capsule **12** can be varied to include many materials. It must conduct heat as well as the food or beverage placed inside the thermodynamic container and must utilize either a change in physical state (solid to liquid or liquid to solid) or a change from one crystalline state to another in the selected temperature range in order to maintain the contents of the thermodynamic container within that range for 30 minutes.

The following materials were actually tested. The transition temperature was noted (melting point, crystallization temperature, temperature of hydration) as well as the heat of transition as reported in the literature.

Material	Transition Temperature	
1. Beeswax	147° F.	42 calories per g.
2. Stearic acid	154° F.	47 calories per g.
3. Triglyceryl stearate	130° F.	45 calories per g.
4. Ferrous sulfate-7-hydrate $FeSo_4.7H_20$	147° F.	56 calories per g.
5. $Na_4B_4O_7.10H_20$	141° F.	68 calories per g.
6. $Ha_2B_2O_4.8H_20$	129° F.	68 calories per g.
7. Refined paraffin	128° F. to 130° F. 133° F. to 135° F. 143° F. to 145° F. 150° F. to 152° F. 160° F. to 165° F.	35 to 58 calories per g. depending on oil content, purity, melting range and the like.
8. Cerro-alloys	119° F. 140° F.	

Together with these materials which undergo a change of state, another material to improve the conductivity of the heat

through the heat-storage medium is needed. Since the conductivity at least equal to that of water was the objective, which would typify the food or beverage conductivity, water itself was used together with crystalline hydrates. In the case of paraffin, a powdered metal was used to replace earlier usage of metal wool. A metal powder flake was selected so less than 1 percent was retained in the 325-mesh sieve. A dispersion of the powder flake was made in a paraffin mixture previously prepared of selected melting-point fractions.

The paraffin mixtures whose heat conductivity was increased with powdered metal were found to react much faster than the salts of hydration and crystallization appearing in the above list. The salts were corrosive in contact with metal containers. Beeswax was expensive and was found to be a poorer conductor of heat than the paraffin and metal composition.

Different metals were tested for addition to the paraffin whose conductivity was found equivalent to cork. Mixtures using powdered copper were definitely faster than those with aluminum. Seventy percent copper was used in one case. The cost of copper was prohibitive, the weight was objectionable, and the toxicity if ingested was disqualifying.

Aluminum of several types was evaluated. Settling occurred with spherical particles and large flakes in low-viscosity mixes. A fine flake (used for pigment applications), less than 1 percent retained on a 325-mesh screen, was retained in molten paraffin for 200 hours with no settling observed in a mixture of 45 percent aluminum powder and 55 percent paraffin. It was found that the spherical aluminum particles of the same mesh size tended to settle out.

The rate of cooling of the contents of the container utilizing the various mixtures of aluminum and paraffin was recorded. The mixture of 20 percent aluminum and 80 percent paraffin did not give enough conductivity to the paraffin mixture to optimize the rate of temperature change of the heat-storage material. With the use of the slower rate of heat transfer, the plateau in the desired range was also shortened. Over 50 percent aluminum powder was unsatisfactory as it appeared that the molten paraffin tended to remain in an amorphous state, was less mobile and did not reflect the same heat of transition as it did when permitted enough fluidity in the molten state to assume better crystallinity in the solid state. Also the time within the desired temperature plateau decreased and, apparently, the crystallization of the paraffin was suffering some interference.

The desired composition for fast cooling to 150°F. and for maximum time in the 130°F. to 150°F. range is 45 percent aluminum powder (99 percent flaked through 325 mesh) and 55 percent paraffin (75 percent with a melting point between 133° F. -135° F. and 25 percent with a melting point between 160° F.-165° F).

Either ceramic or plastic may be used in the outer shell **20**.

After screening a series of adhesives in a heating-cooling cycle with exposure to water as in a dishwashing cycle, a epoxypolysulfide adhesive was selected to bond the metal capsule to the plastic outer shell. ABS and polypropylene were selected as materials for the other shell because of their comparatively low cost and high-heat distortion temperature. A flexible adhesive is necessary because of the different coefficients of expansion of the capsule and the outer shell.

To minimize the heat loss from the outer shell, an insulation layer of felt or plastic foam is used between the metal capsule and plastic outer shell. The insulation material **22** and its distribution in the thermodynamic container are best seen in FIG. 2.

From the foregoing, those skilled in the art will readily understand and appreciate the nature and utility of the invention and the manner in which it achieves and realizes the objects and advantages over the previous art disclosed in my abandoned U.S. Pat. application, Ser. No. 141,814, and also disclosed in the Zimmerman Pat. No. 2,876,634. In this invention, the inclusion of a metal capsule as a means for containing the heat-storage material surrounded on one side by insulation material and adhesively bonded to an outer shell permits heat to rapidly pass from the hot beverage into the walls of the capsule and enter the heat-storage material from all sides. In combination with the dispersion of metal flakes throughout the heat-storage material, a conduction of heat is possible at a much faster rate than obtainable in earlier models of the prior art.

Adhesive bonding between the inner capsule and the outer shell provides much greater flexibility than obtainable by a threaded connection.

The novelty of using a cutaway sectional can adhesively bonded to an outer attachment readily lends itself to mass production.

The insulation separating the inner metal capsule from the outer shell essentially solves the problem of heat loss through the outer shell that was inherent in the design of models of the prior art.

Selection of any of various compositions for a heat-storage material will allow a beverage at 190°-200° F. to be cooled within 2 minutes to a selected temperature range of 110°-120° F., 120°-130° F. 130°-140° F., and the like and to be maintained in that range for a period of 30 minutes.

The foregoing disclosure is representative of a preferred form of the invention and is to be interpreted in an illustrative rather than a limiting sense, the invention to be accorded the full scope of the claims appended hereto.

I claim:

1. A thermodynamic container comprising
an outer shell,
a hollow internal capsule being attached to said outer shell so that a space is provided between said outer shell and said internal capsule, and
a heat-storage material exhibiting a change of state in the range of 150° F. to 120° F. and contained inside of the walls of said internal capsule.

2. A thermodynamic container as in claim 1 in which said internal capsule is adhesively bonded to said outer shell.

3. A thermodynamic container as in claim 1 in which said space between said internal capsule and said outer shell is filled with insulation material.

4. A thermodynamic container as in claim 1 in which said internal capsule is made of aluminum.

5. A thermodynamic container as in claim 1 in which said heat-storage material has the composition of essentially 45 percent aluminum powder and essentially 55 percent paraffin.

6. A thermodynamic container as in claim 2 in which said adhesive is a epoxypolysulfide adhesive.

7. A thermodynamic container as in claim 1, in which said insulation material is a plastic foam.

8. A thermodynamic container as in claim 1, in which said insulation material in felt.

9. A thermodynamic container as in claim 1 wherein said outer shell is composed of a material having a low thermal conductivity and said internal capsule is composed of a material with a high thermal conductivity.

United States Patent

[11] 3,603,106

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[21] Appl. No. 810,957
[22] Filed Mar. 27, 1969
[45] Patented Sept. 7, 1971

[54] **THERMODYNAMIC CONTAINER**
9 Claims, 3 Drawing Figs.

[52] U.S. Cl. 62/457, 62/471, 220/14, 126/400
[51] Int. Cl. F25d 3/08
[50] Field of Search 62/457, 471; 220/14; 126/400

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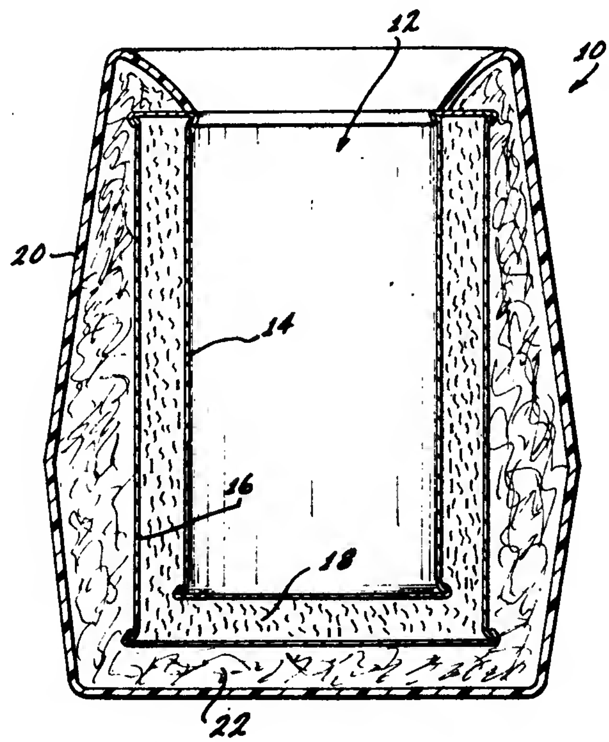
Primary Examiner—William J. Wye
Attorney—Herzig & Walsh

ABSTRACT: This invention relates to food and beverage containers and more particularly to containers of the thermodynamic type capable of regulating the temperature of the food and beverage therein. The thermodynamic container disclosed herein comprises an outer wall of low thermal conductivity separated by an insulating material from an inner metal capsule of very high thermal conductivity having a heat-storage material disposed therein. Beverages too hot to drink melt the heat-storage material which in turn cools the beverage to a drinkable temperature within two minutes. Heat lost during the beverage's cooling is then returned to the beverage to maintain it at a drinkable temperature as the heat-storage material resolidifies.



PATENTED SEP 7 1971 3,603,106

FIG. 1

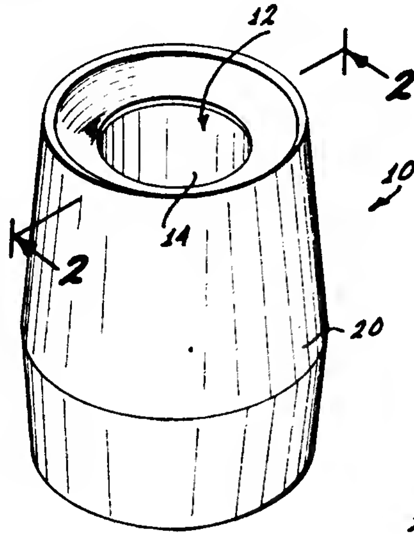
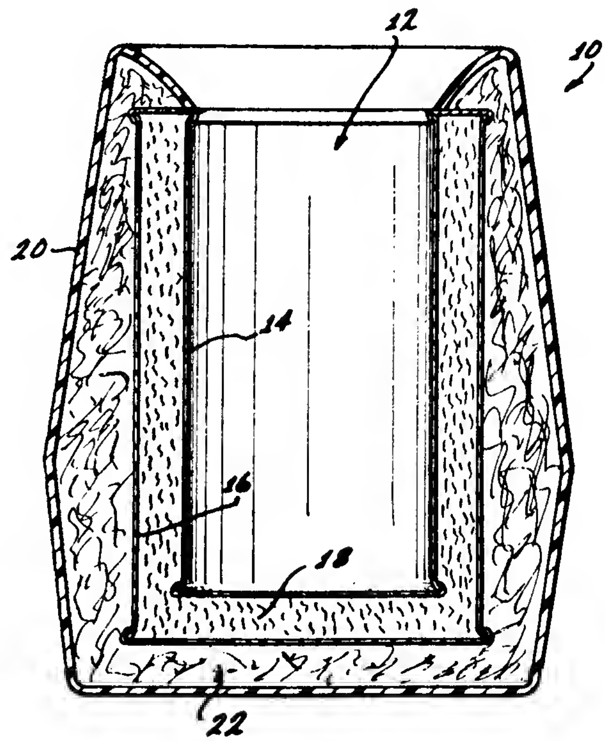


FIG. 2



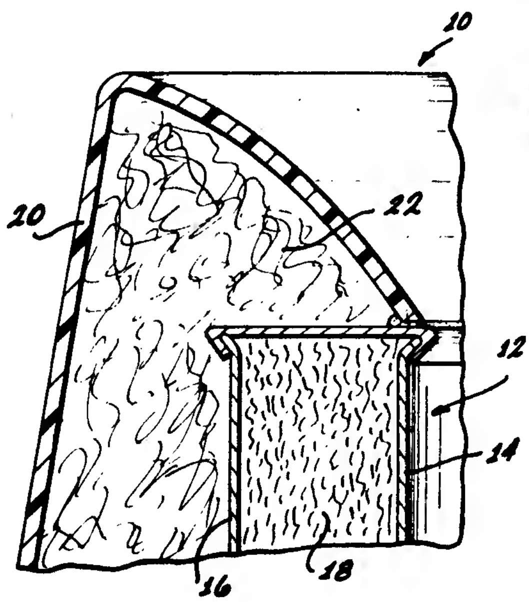


FIG. 3

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